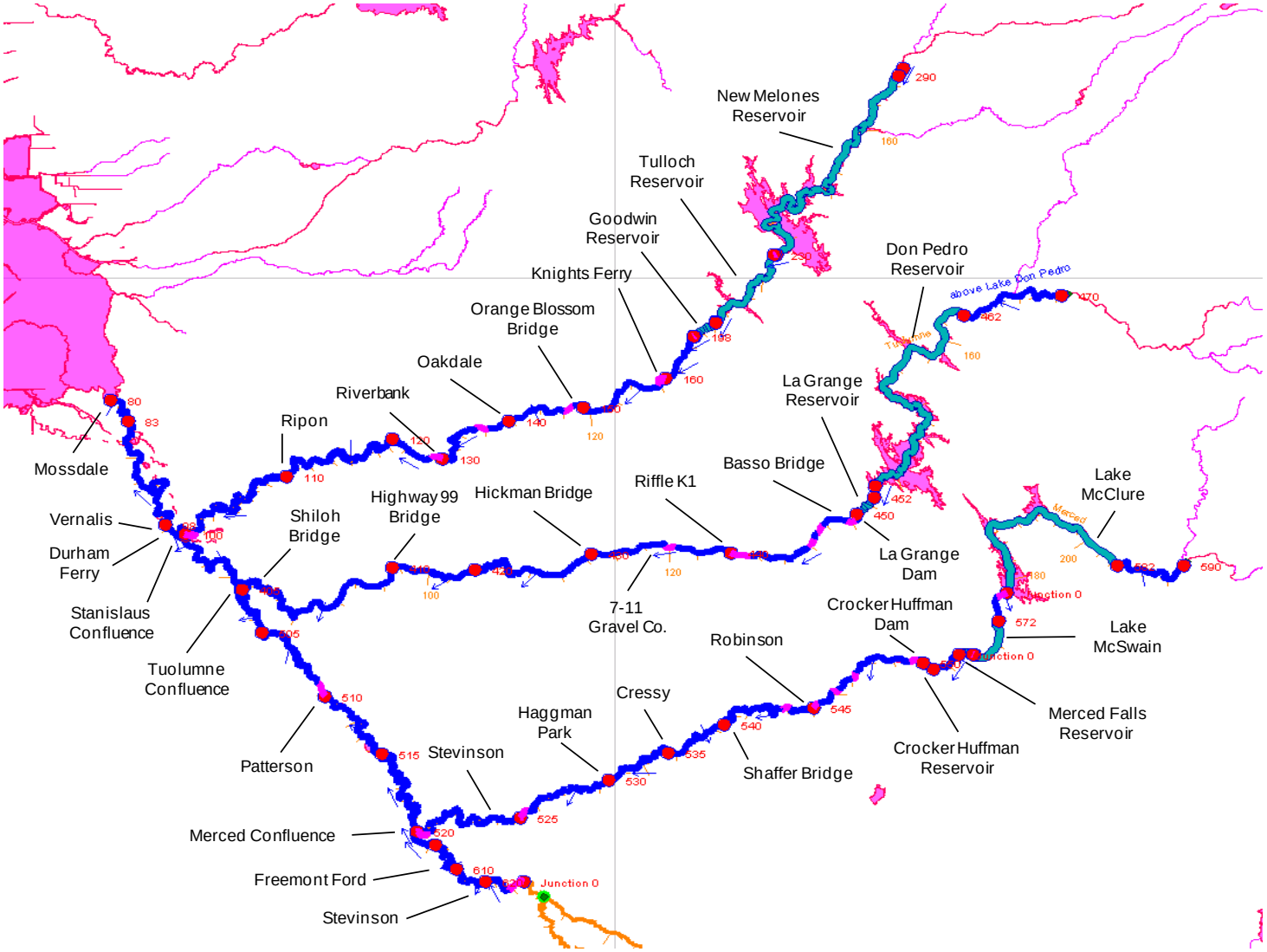
Water Temperature Modeling for 2009 OCAP BA Using the CALFED San Joaquin River Basin Water Temperature Model



San Joaquin River Basin Water Temperature Model
Model Evolution

- Phase I – Stanislaus River Only – 2002

  Grass-roots project funded by Stanislaus Stakeholders: USBR, USFWS, CDFG, OID, SSJID, & SEWD

- Phase II – Stanislaus-Lower SJR – 2007

  Funded by CALFED – ERP, endorsed by Stanislaus Stakeholders

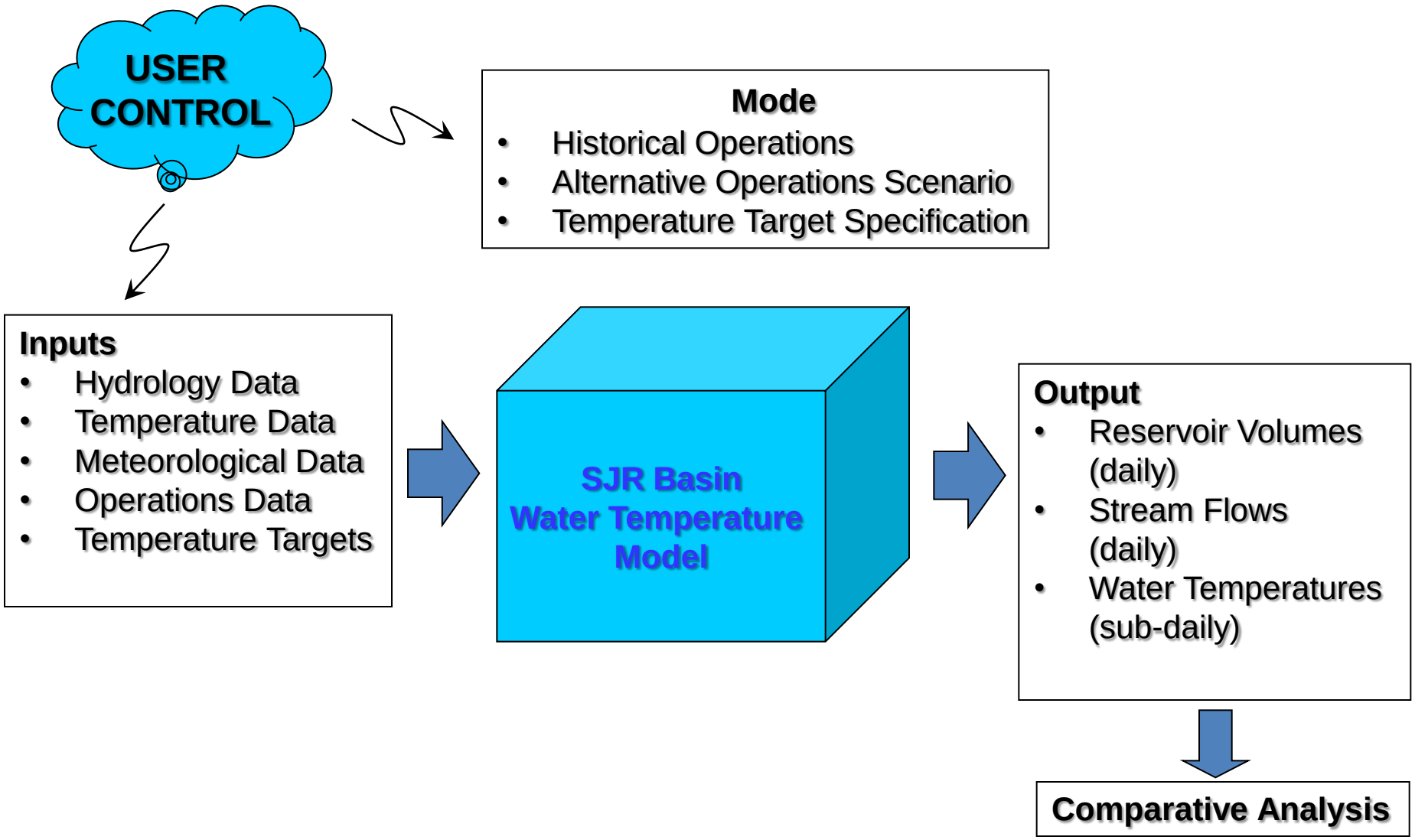
- Phase III – SJR Basin-Wide – 2008, 2009

  Funded by CALFED – ERP, endorsed by Stanislaus, Tuolumne and Merced Stakeholders

The Team

- Tri-Dam – Project Coordinator
- Avry Dotan, AD Consultants – Project Manager
- Don Smith, RMA – Principal Modeler
- Mike Deas, Watercourse Engineering – Modeler
- CDFG – Data Collection and Management
- Peer Review – Temperature Criteria
  - Mike Deas – Chair, Watercourse Engineering
  - John Bartholow, USGS
  - Chuck Hanson, Hanson Environmental, Inc.
  - Chris Myrick, Colorado State
- Peer Review – Model
  - Independent group of scientists assembled by UC Davis

Modeling Control Elements



Global Model Modes

1. Historical Operations:
   - Reproduce historical conditions/operations for calibration
   - Can form a baseline condition for comparative analysis
2. Alternative Operations Scenario:
   - Top down approach: Define operations scenario and examine temperature response
3. Temperature Target Specification:
   - Bottom up: Define location, period of time, target temperature and operate to meet these conditions

Operations Scenarios Evaluated with the Model in Connection with the OCAP BA:

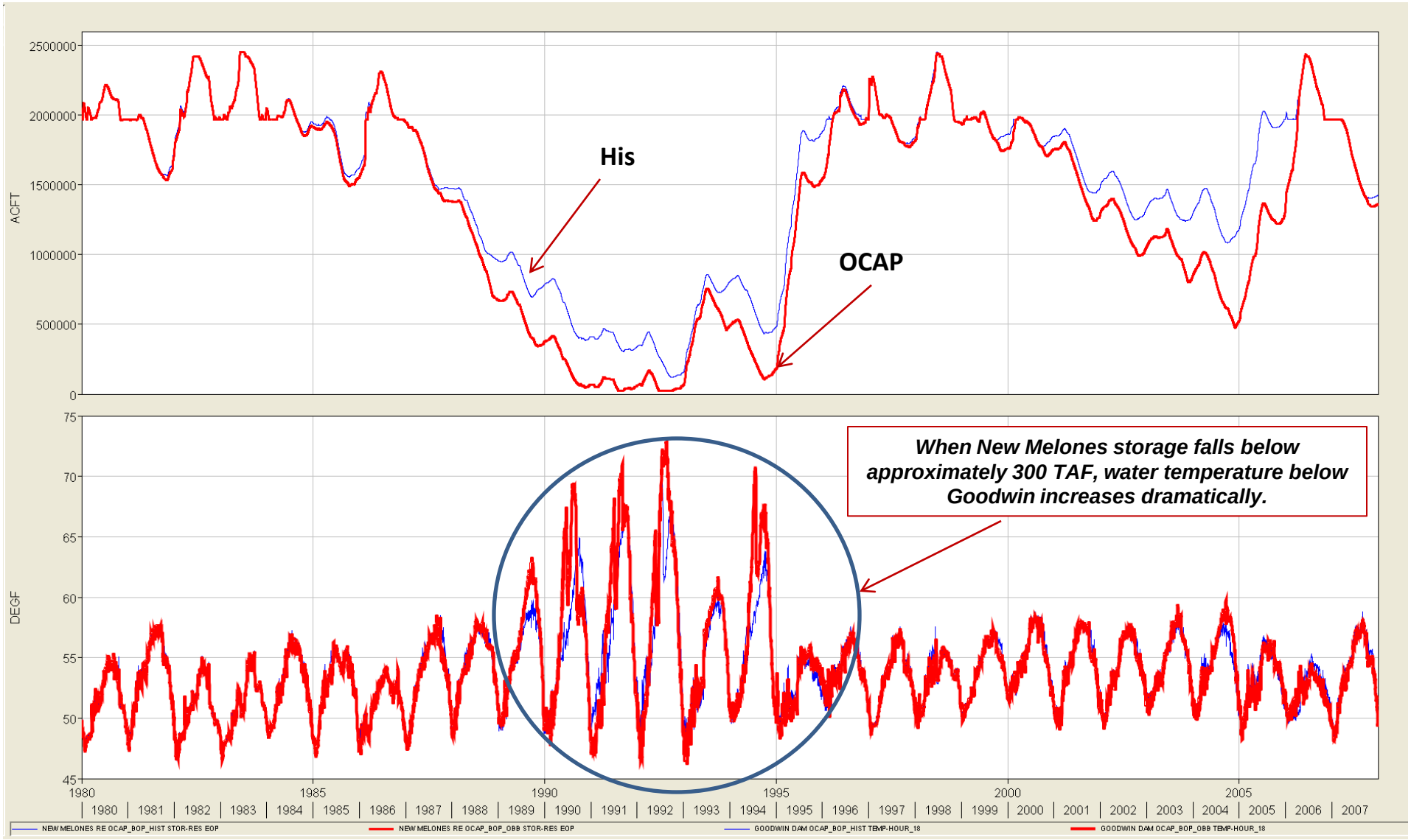
Cases:

- HIS – Historical Operation (reference case)
- OCAP – Historical Instream Flow, Augmented to Meet Temperature Target at OBB

Assumptions:

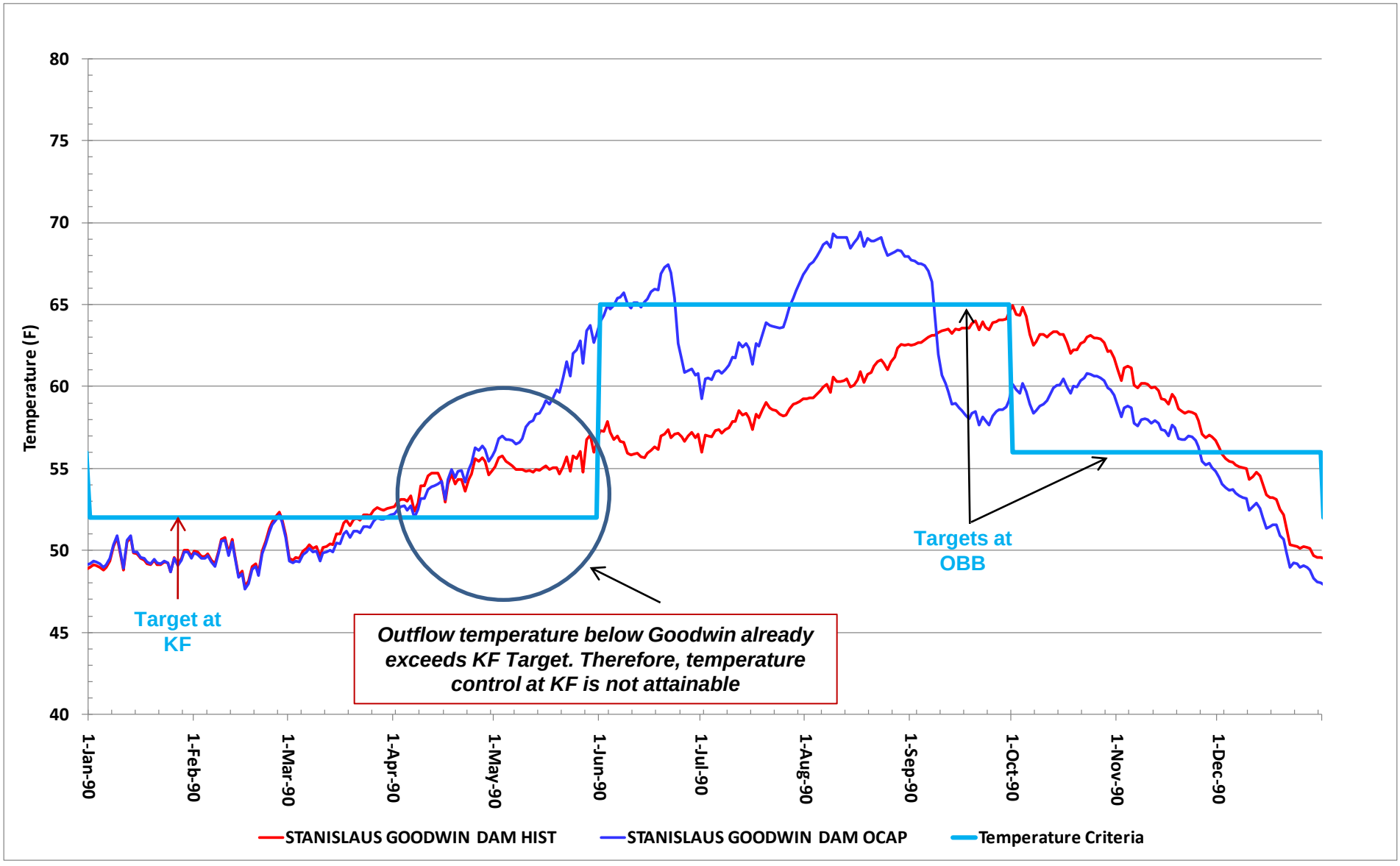
- Augmentation to meet Orange Blossom Bridge (OBB) Temperature Targets
  - His – N/A
  - OCAP – Yes
- Conditions when Augmentation Stops
  - His – N/A
  - OCAP - When Tulloch Flow exceeds 2,060 cfs (see slide: Temperature Control Limitation in the Stanislaus system) or when New Melones storage is below 350 TAF
- Districts Diversions Equal to Historical (all cases)
- Minimum Goodwin Controlled Release:
  - His – Historical operation
  - OCAP – Historical non-flood flow (including DO, WQ, fish release, etc.)
- Maximum Goodwin Controlled Release:
  - His – Historical operation
  - OCAP – As much as needed to meet target but not to exceed 2,060 cfs at Tulloch

New Melones Storage is depleted due to increased releases above Historical to meet OCAP Temperature Targets (1980-2007)



New Melones Storage - Critical Year 1990

Temperature Below Goodwin Dam in Relation to Target Temperature at Knights Ferry (KF) and Orange Blossom Bridge (OBB)
Example: 1990 (similar phenomenon would occur 90% of the time)

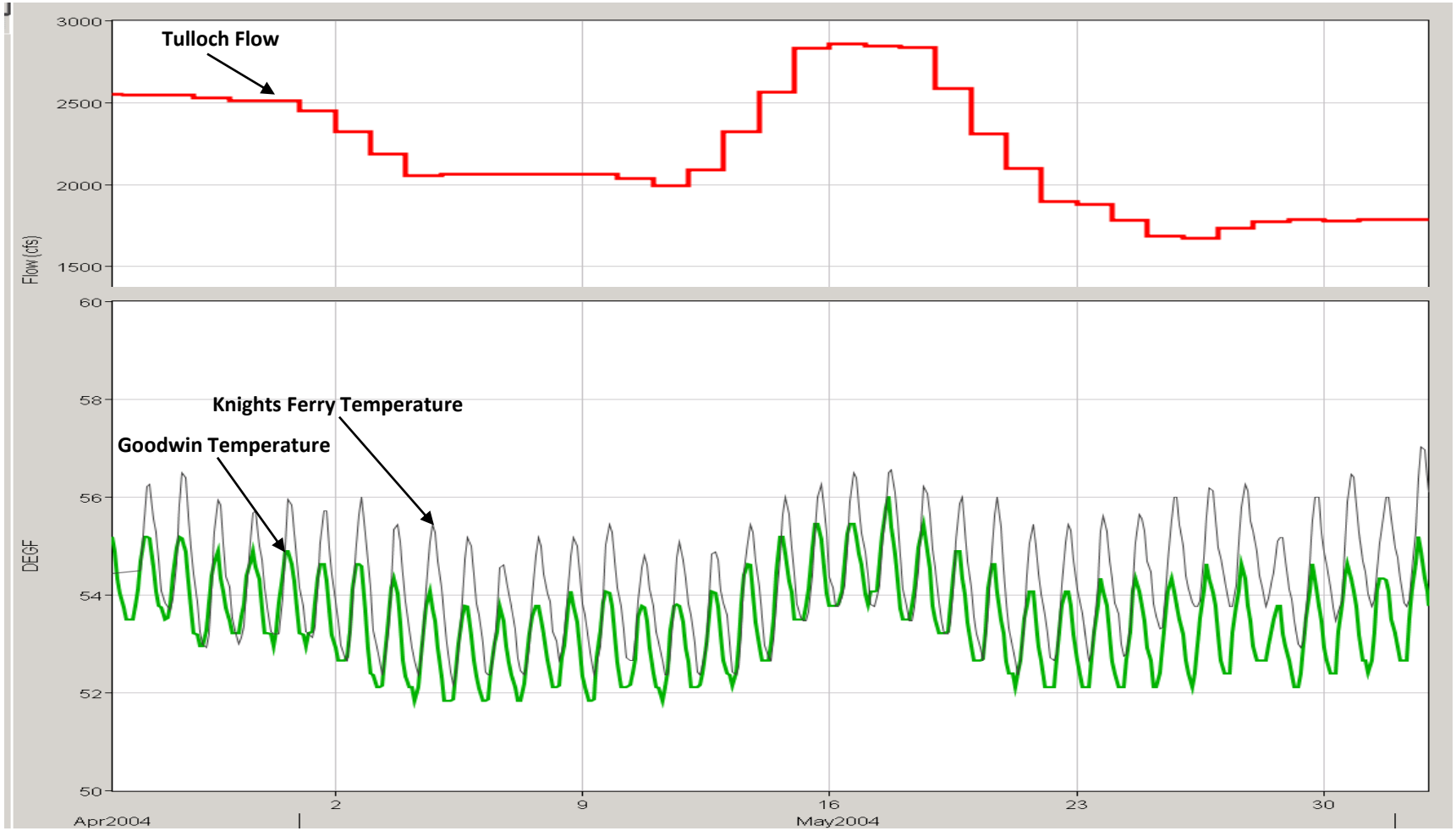


Temperature Control Limitation in the Stanislaus system

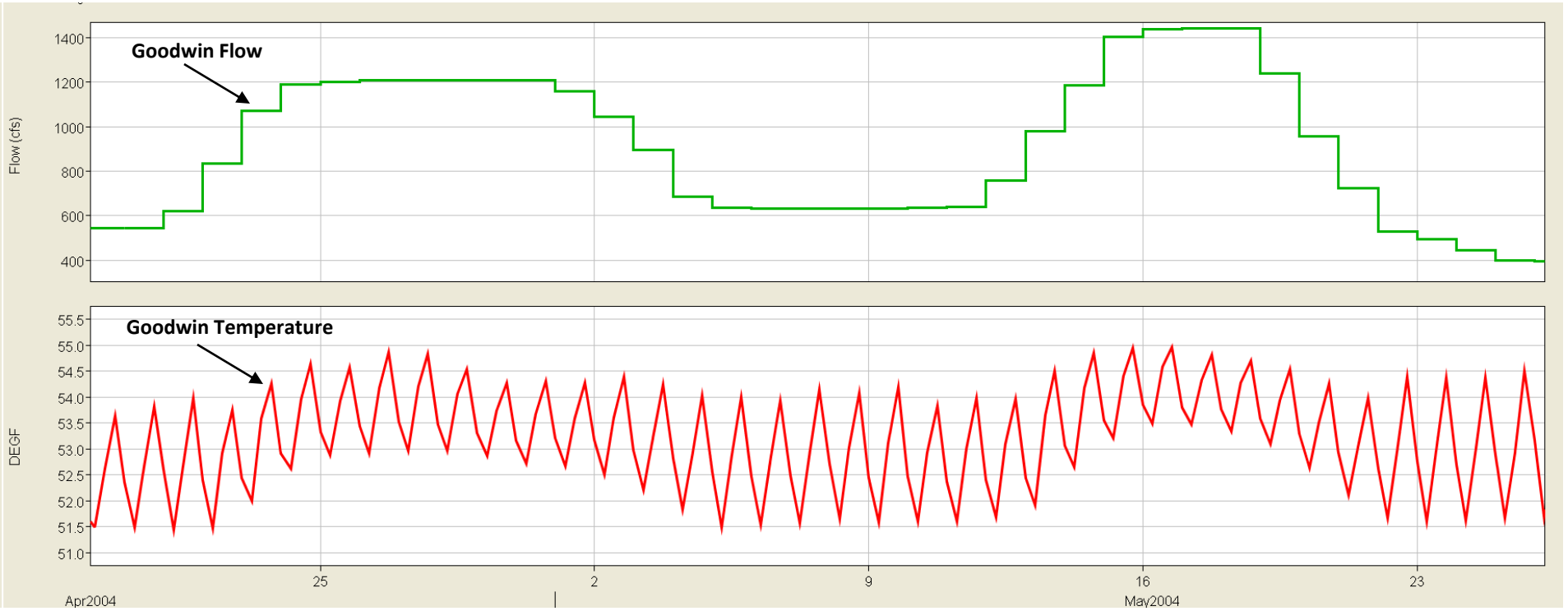
The low level outlet capacity of Tulloch Dam is approximately 2,060 cfs. Any additional flow above 2,060 cfs has to be release through the Tulloch spillway. This flow is discharged over the spillway crest. The temperature of the spilled water is higher than the flow through the low level outlet. In addition, by the time the water reaches Goodwin Dam, there will be additional heating process going on over the rocks downstream of the spillway and in Goodwin pool itself. Finally, the top layer of water in Goodwin pool, which is the warmest, is discharged downstream for fish flow. So, higher releases that trigger Tulloch spills will cause higher water temperature below Goodwin.

This phenomenon is supported by observed data as well as Model results, as illustrated in the following slides:

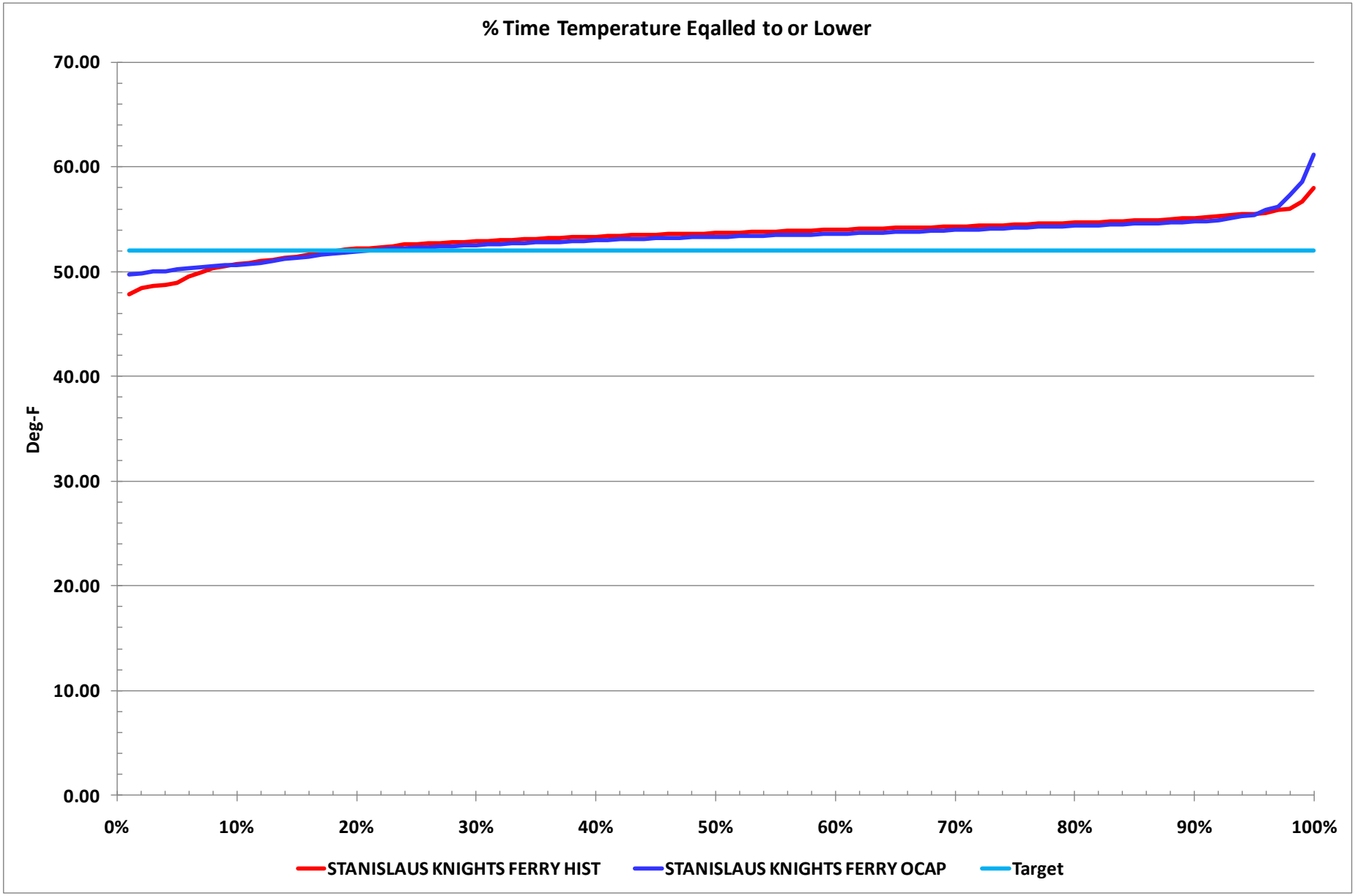
Example of Tulloch Spill (Q<2,060 cfs) on Goodwin & Knights Ferry Temperature
New Melones Volume = 1,500 TAF
(based on observed data)



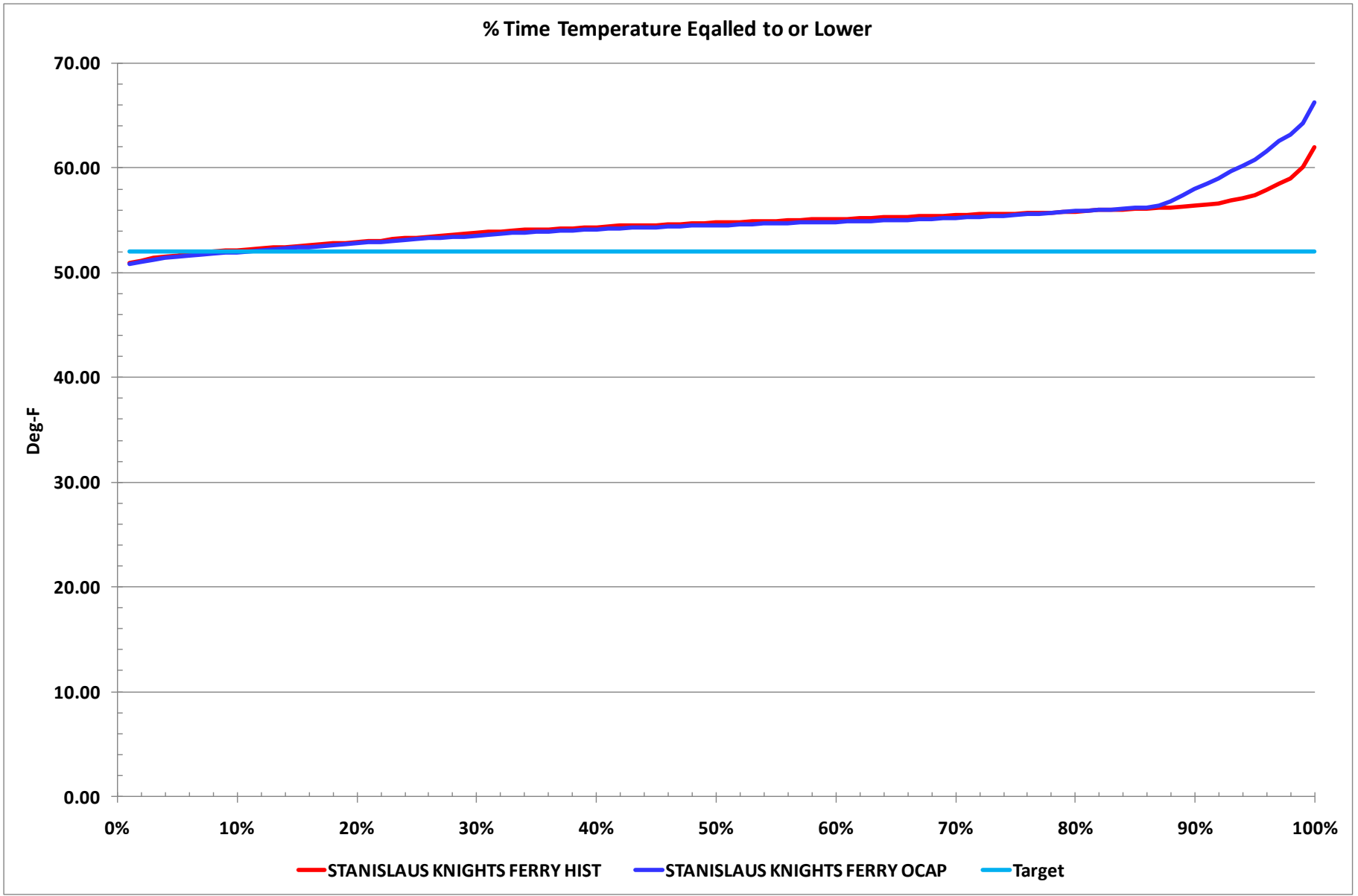
Increased flow below Goodwin because of Tulloch Spills, results in Increased Temperatures
New Melones Volume = 1,500 TAF
(based on simulated historical operation)



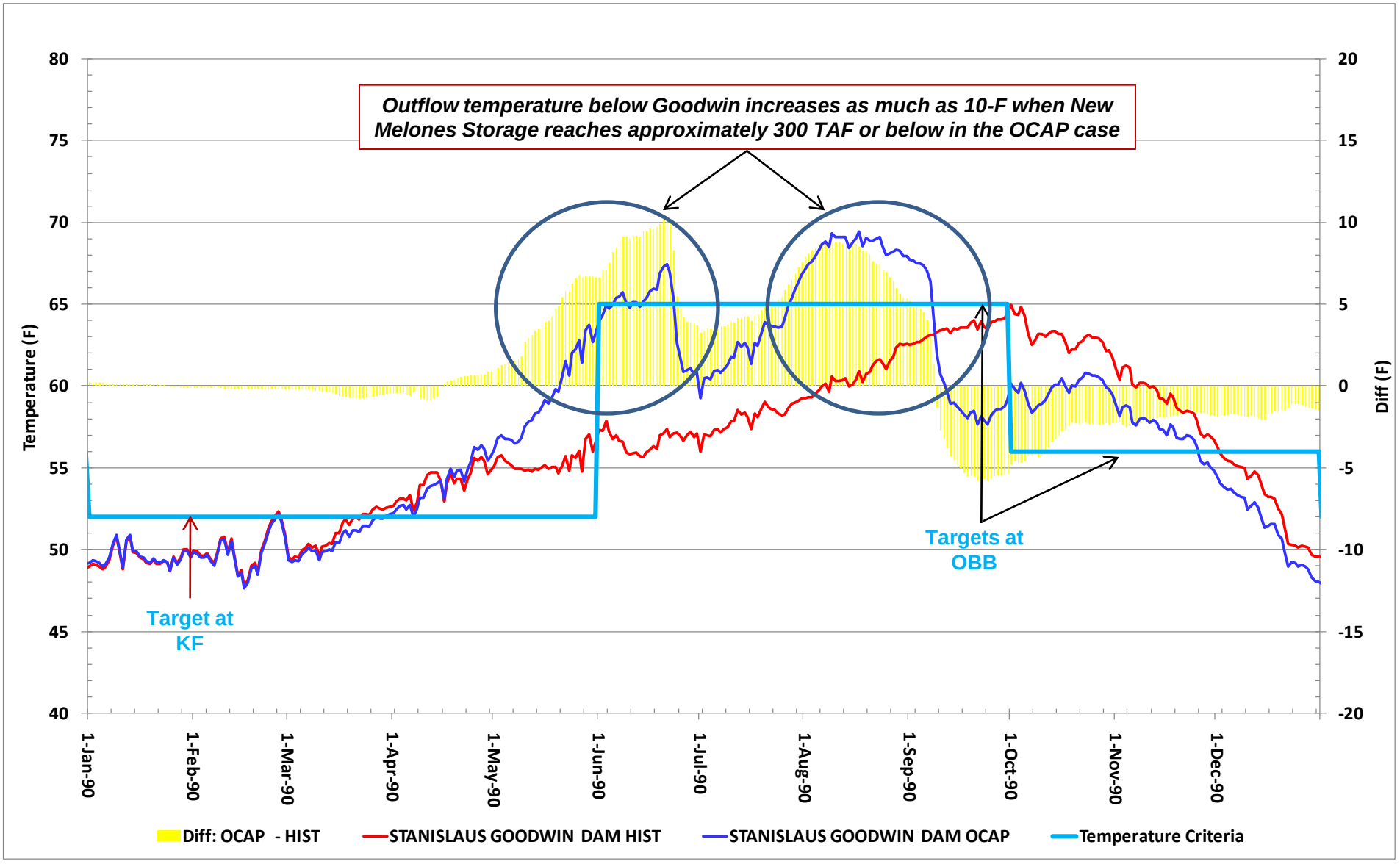
Target temperature at Knights Ferry can be met only about 20% of the time in the month of April with or without flow augmentation



Target temperature at Knights Ferry can be met only about 10% of the time in the month of May with or without flow augmentation



Temperature Below Goodwin Dam in Relation to Target Temperature at Knights Ferry (KF) and Orange Blossom Bridge (OBB)
Example: 1990



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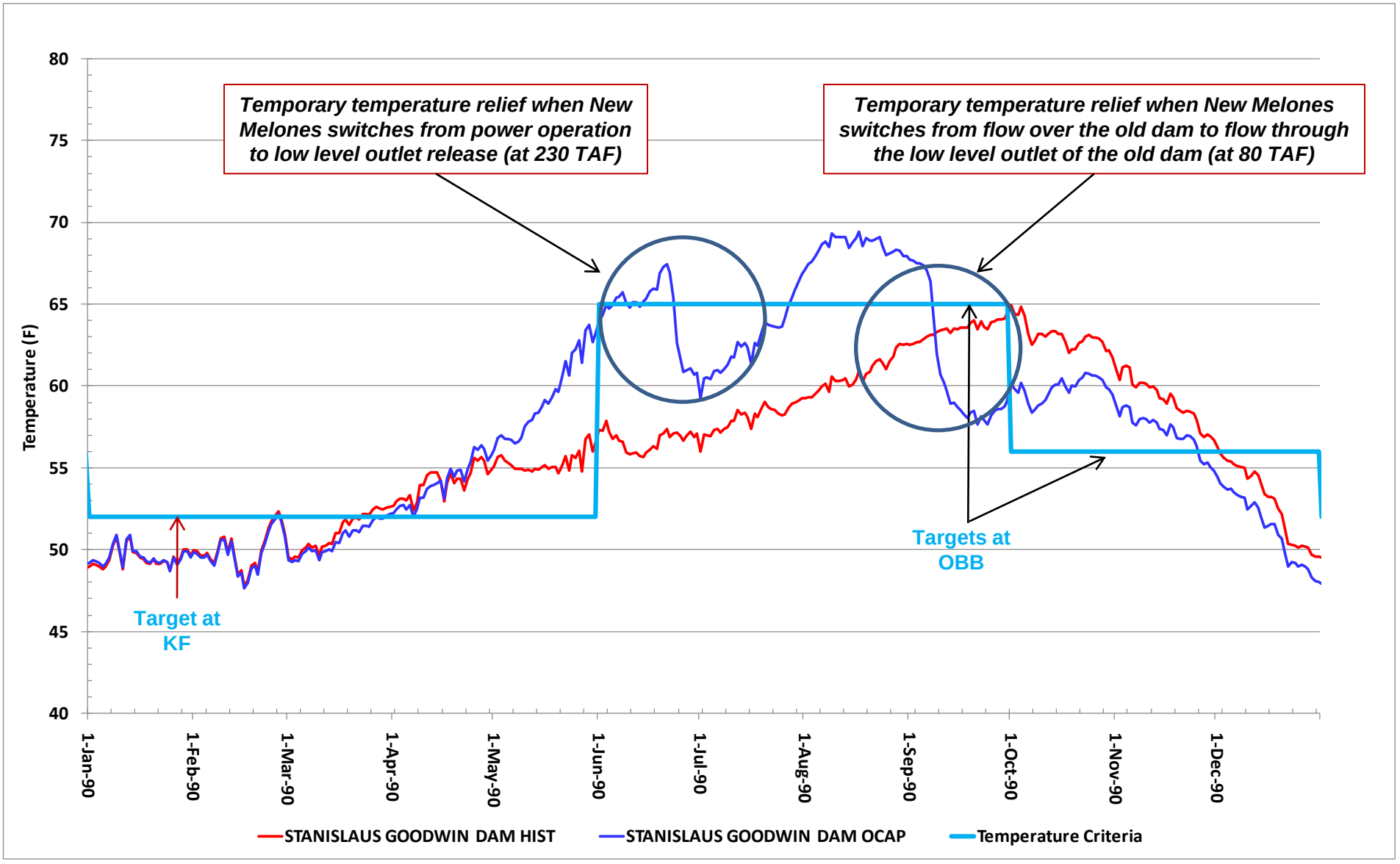
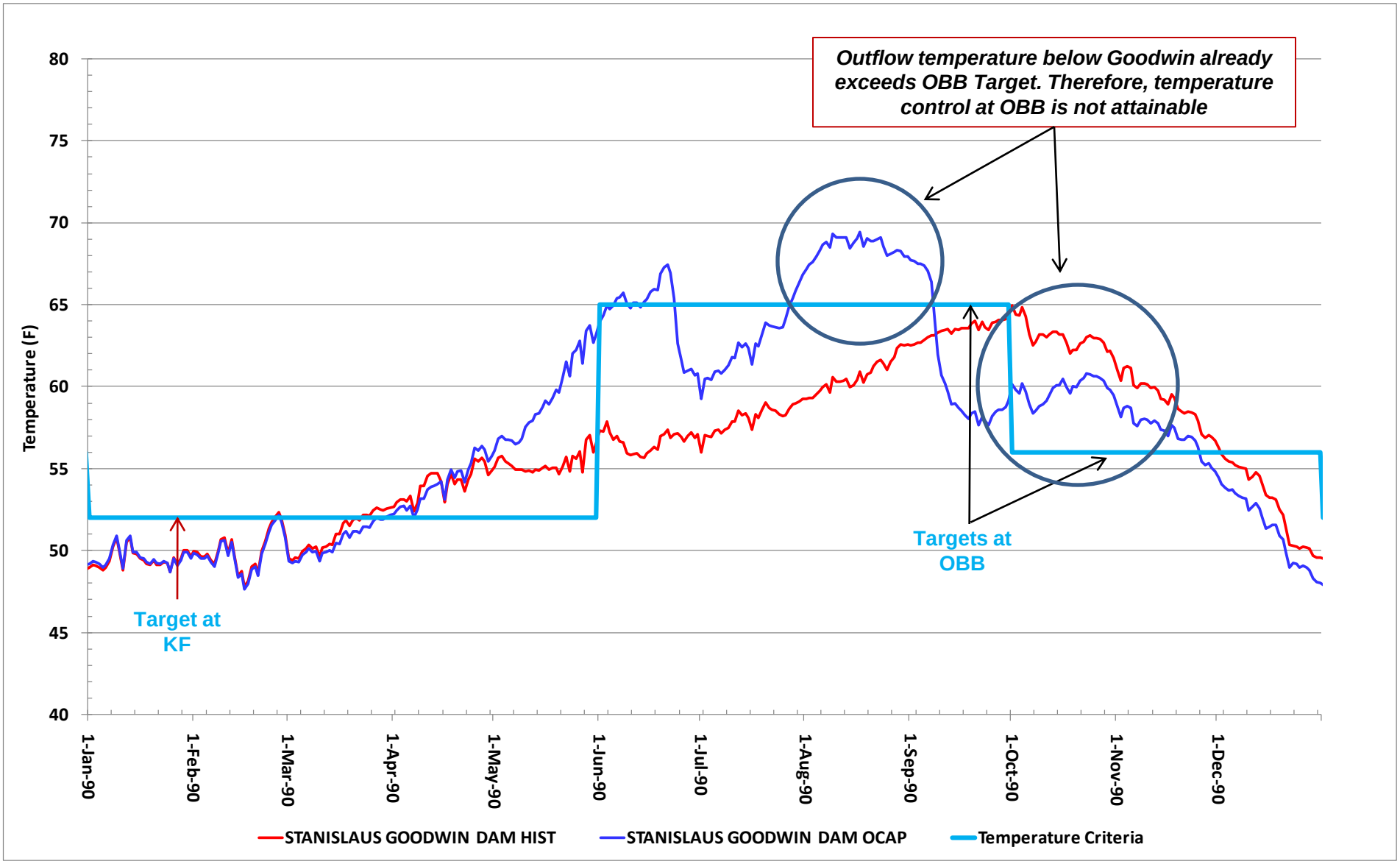
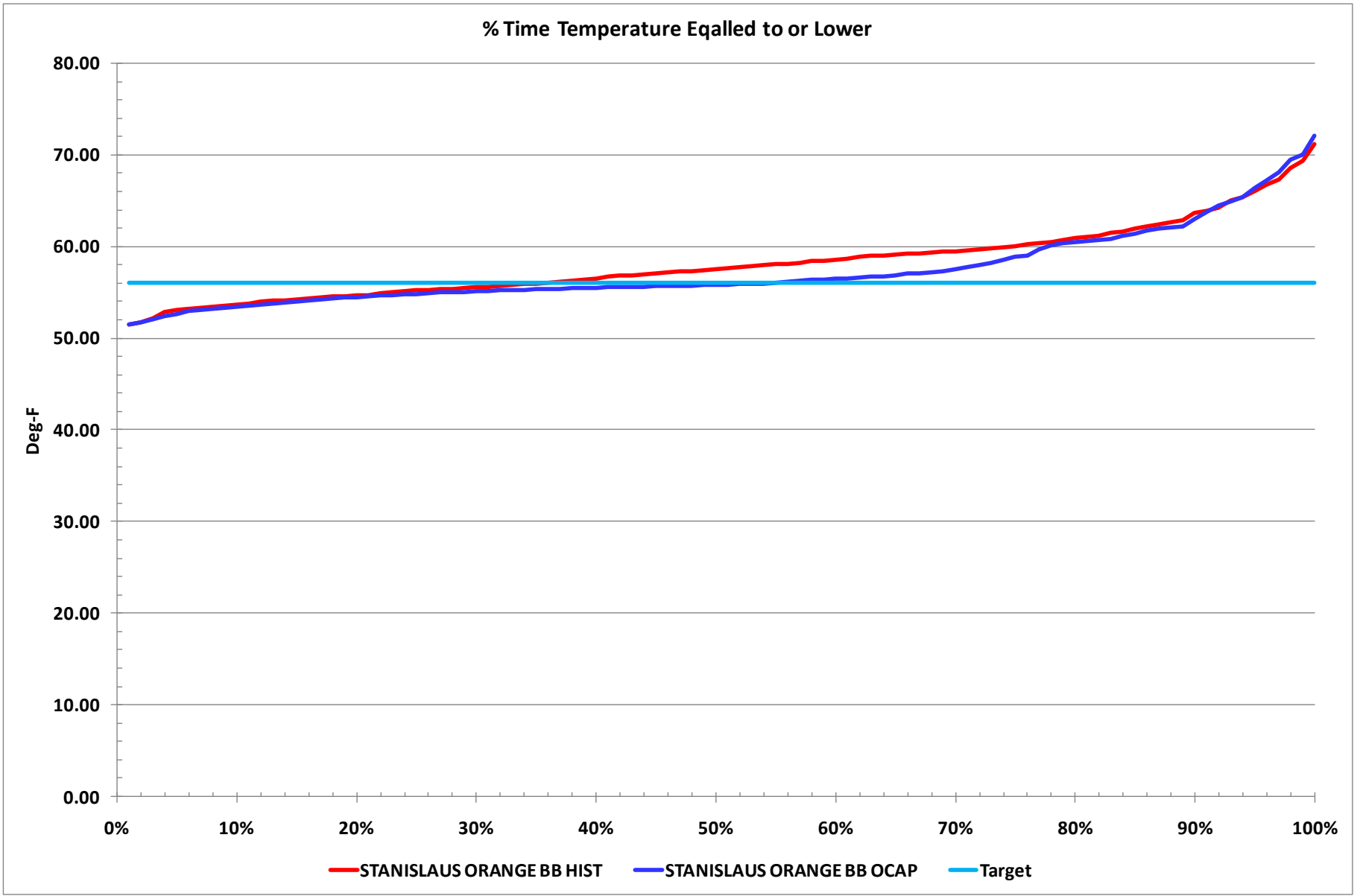


Temperature Below Goodwin Dam in Relation to Target Temperature at Knights Ferry (KF) and Orange Blossom Bridge (OBB)
Example: 1990

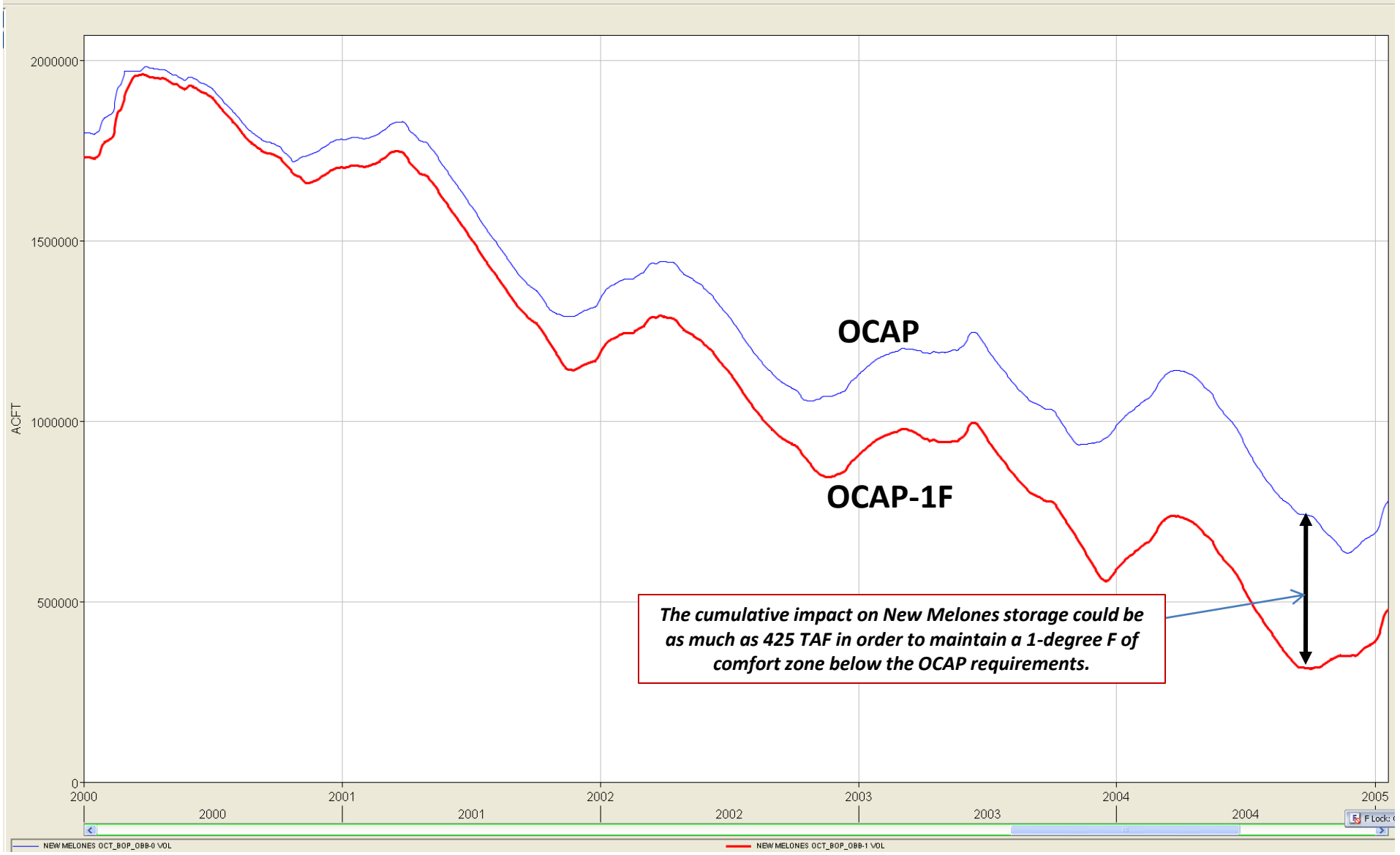


Target temperature at Orange Blossom Bridge can be met only about 50% of the time in the month of October even after flow augmentation (about 15% increase over Historical)



Practical aspect of meeting targets at OBB per OCAP:

Water managers usually maintain a buffer, or a comfort zone, when operating the reservoirs to meet downstream regulatory requirements. The chart below shows the potential impact on New Melones storage by keeping a comfort zone of 1-degree F below the OCAP targets in order to ensure temperature compliance



Other Operations Scenarios Evaluated with the Model:

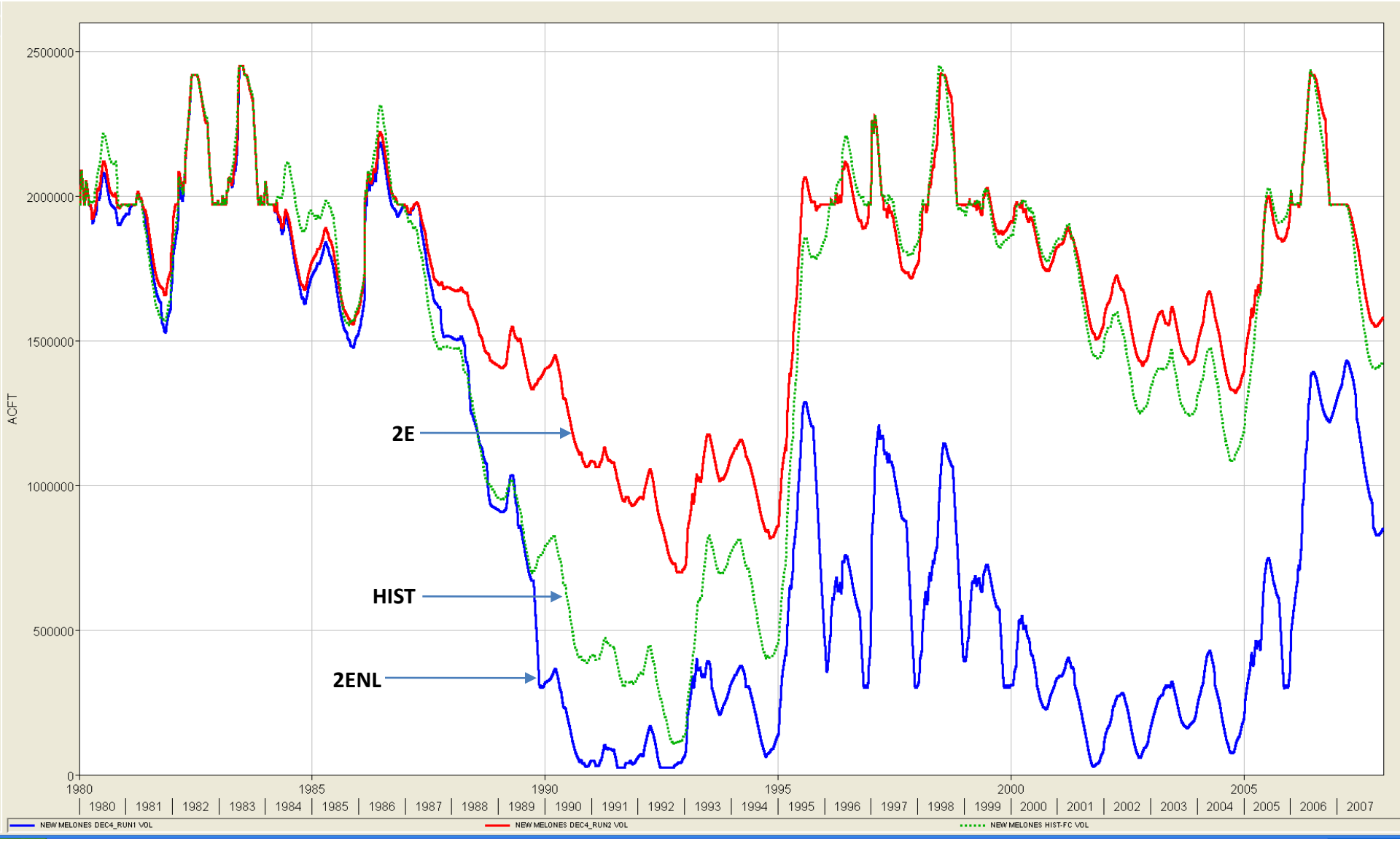
Cases:

- HIST – Historical Operation (reference case)
- 2E – Instream Flow per Table 2E
- 2ENL – Instream Flow per Table 2E, Augmented to Meet Temperature Target at OBB

Assumptions:

- Augmentation to meet OBB Temperature Target
  - 2E – No
  - 2ENL – Yes
- Conditions when Augmentation Stops
  - 2E – N/A
  - 2ENL - ONLY when Goodwin Flow Exceeds Channel Capacity (assumed 5,000 cfs)
- Districts Diversions Equal to Historical (all cases)
- Minimum Goodwin Controlled Release:
  - 2E – Table 2E (minimum flow by year type)
  - 2ENL - Table 2E (minimum flow by year type)
- Maximum Goodwin Controlled Release:
  - 2E – per Table 2E
  - 2ENL – Goodwin channel capacity (5,000 cfs)

New Melones Storage



Percent of the time maximum temperatures equal to or less than OBB Target

2E vs. 2ENL

%EXC	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
2%	45.6	45.5	47.9	47.7	49.0	48.6	50.3	49.6	52.4	51.6	52.2	52.4	54.3	54.2	59.1	59.0	55.6	55.5	52.1	51.9	50.0	49.9	46.3	46.4
4%	46.3	46.2	48.3	48.0	49.1	48.8	50.7	50.0	53.0	51.9	53.6	53.4	56.5	56.8	59.3	59.3	56.3	56.4	52.7	52.9	50.6	50.5	46.7	47.0
6%	46.6	46.4	48.6	48.3	49.3	49.0	51.2	50.3	53.3	52.1	53.9	53.8	57.8	57.9	59.5	59.5	57.2	57.2	53.0	53.1	50.9	50.8	47.6	47.7
8%	46.8	46.6	48.7	48.5	49.6	49.2	51.4	50.4	53.6	52.3	54.4	54.1	58.5	58.6	59.7	59.7	57.7	57.8	53.2	53.3	51.3	51.2	48.1	47.9
10%	47.1	46.8	48.9	48.7	49.8	49.3	51.8	50.6	53.8	52.6	54.7	54.3	59.5	59.5	59.9	59.9	58.0	58.1	53.4	53.6	51.5	51.6	48.5	48.3
12%	47.2	47.0	49.0	48.8	50.1	49.5	52.0	50.8	54.0	52.7	55.2	54.6	59.9	60.0	60.3	60.1	58.2	58.6	53.7	53.8	51.7	51.8	48.7	48.6
14%	47.5	47.2	49.2	48.9	50.5	49.6	52.3	51.1	54.1	52.9	55.4	54.8	60.3	60.2	60.6	60.4	58.4	58.9	53.8	54.1	51.8	51.9	48.9	48.8
16%	47.7	47.3	49.3	49.0	50.8	49.8	52.4	51.2	54.2	53.1	55.6	55.0	60.6	60.5	60.8	60.7	58.7	59.2	53.9	54.4	52.0	52.2	49.1	48.9
18%	47.9	47.5	49.4	49.1	51.0	50.1	52.7	51.4	54.4	53.3	55.9	55.2	60.8	60.8	61.0	60.9	58.9	59.6	54.1	54.7	52.1	52.5	49.2	49.1
20%	48.1	47.6	49.5	49.2	51.2	50.2	52.9	51.6	54.5	53.5	56.2	55.4	61.2	61.2	61.1	61.2	59.2	59.9	54.3	55.0	52.2	52.8	49.3	49.2
22%	48.2	47.7	49.6	49.4	51.4	50.4	53.1	51.8	54.6	53.6	56.4	55.6	61.4	61.4	61.2	61.6	59.3	60.3	54.4	55.2	52.3	52.9	49.5	49.3
24%	48.3	47.8	49.7	49.5	51.5	50.5	53.2	52.0	54.8	53.8	56.7	55.9	61.7	61.8	61.4	62.2	59.5	60.6	54.6	55.5	52.5	53.1	49.6	49.5
26%	48.4	48.0	49.9	49.6	51.6	50.6	53.4	52.2	54.9	54.0	56.8	56.3	62.0	62.3	61.5	62.6	59.6	60.8	54.8	55.6	52.6	53.3	49.7	49.6
28%	48.5	48.1	50.0	49.7	51.9	50.8	53.5	52.4	55.1	54.1	57.0	56.5	62.3	62.8	61.7	63.0	59.8	61.0	55.0	55.8	52.7	53.5	49.8	49.7
30%	48.6	48.3	50.0	49.8	52.1	50.9	53.7	52.6	55.2	54.4	57.2	56.8	62.6	63.2	62.0	63.3	59.9	61.3	55.1	55.9	52.9	53.8	49.9	49.8
32%	48.7	48.4	50.1	49.9	52.2	51.0	53.9	52.8	55.4	54.5	57.4	57.0	62.8	63.5	62.1	63.7	60.1	61.4	55.3	56.0	53.0	54.1	50.0	50.0
34%	48.7	48.4	50.2	50.0	52.3	51.1	54.0	53.1	55.5	54.7	57.6	57.3	63.0	64.0	62.3	63.8	60.2	61.7	55.4	56.1	53.2	54.2	50.1	50.1
36%	48.8	48.5	50.3	50.1	52.4	51.2	54.2	53.2	55.5	54.8	57.8	57.6	63.2	64.2	62.5	64.0	60.4	61.8	55.6	56.5	53.3	54.5	50.2	50.2
38%	48.9	48.6	50.3	50.2	52.5	51.3	54.3	53.3	55.6	55.0	58.0	57.8	63.5	64.3	62.7	64.2	60.6	62.0	55.7	57.1	53.4	54.7	50.3	50.3
40%	49.0	48.7	50.4	50.2	52.6	51.5	54.4	53.5	55.7	55.2	58.2	58.0	63.7	64.5	63.0	64.3	60.8	62.2	55.9	57.3	53.5	54.9	50.3	50.5
42%	49.0	48.8	50.6	50.4	52.7	51.6	54.6	53.7	55.8	55.3	58.5	58.3	64.0	64.6	63.2	64.4	61.0	62.4	56.0	57.6	53.7	55.1	50.4	50.5
44%	49.1	48.9	50.6	50.5	52.9	51.9	54.7	53.9	55.9	55.5	58.7	58.5	64.4	64.7	63.4	64.5	61.2	62.7	56.1	57.8	53.7	55.3	50.5	50.7
46%	49.2	49.0	50.7	50.6	53.0	52.1	54.9	54.1	56.0	55.7	59.4	59.0	64.8	64.7	63.7	64.6	61.3	62.9	56.2	58.2	53.8	55.6	50.6	50.9
48%	49.2	49.0	50.9	50.7	53.1	52.3	55.1	54.3	56.2	55.8	60.3	59.8	65.1	64.8	64.0	64.7	61.5	63.2	56.4	58.5	53.9	55.9	50.7	51.0
50%	49.3	49.1	51.0	50.8	53.3	52.5	55.3	54.4	56.3	56.0	61.4	60.6	65.7	64.8	64.2	64.8	61.6	63.3	56.5	58.7	54.0	56.0	50.7	51.1
52%	49.3	49.2	51.1	50.9	53.4	52.7	55.4	54.7	56.5	56.2	62.8	61.2	66.2	64.9	64.4	64.8	61.7	63.4	56.7	58.9	54.1	56.2	50.8	51.2
54%	49.4	49.3	51.1	51.0	53.5	52.8	55.5	55.1	56.7	56.3	63.8	62.2	66.4	65.0	64.5	64.9	61.9	63.6	56.8	59.2	54.2	56.5	50.9	51.3
56%	49.5	49.4	51.2	51.1	53.7	53.1	55.7	55.2	56.8	56.5	64.1	62.9	66.7	65.0	64.8	65.0	62.0	63.7	57.0	59.5	54.3	56.8	51.0	51.4
58%	49.5	49.5	51.3	51.2	53.8	53.3	55.8	55.6	57.0	56.7	64.5	63.8	66.9	65.1	65.0	65.0	62.2	63.9	57.1	59.9	54.4	57.2	51.1	51.6
60%	49.6	49.5	51.4	51.3	54.0	53.5	55.9	55.8	57.1	56.8	64.8	64.3	67.0	65.1	65.2	65.1	62.4	64.1	57.2	60.4	54.5	57.3	51.2	51.8
62%	49.7	49.6	51.5	51.4	54.2	53.8	56.1	56.0	57.3	57.0	65.2	64.5	67.2	65.2	65.4	65.3	62.6	64.2	57.3	60.5	54.6	57.6	51.3	52.0
64%	49.7	49.7	51.6	51.5	54.5	54.1	56.3	56.3	57.5	57.1	65.4	64.7	67.4	65.3	65.6	65.6	62.7	64.4	57.6	60.6	54.6	57.8	51.3	52.2
66%	49.8	49.8	51.7	51.6	54.8	54.5	56.4	56.4	57.7	57.3	65.6	64.8	67.6	65.4	65.8	68.0	62.8	64.5	57.8	60.8	54.7	57.9	51.4	52.4
68%	49.9	50.0	51.8	51.7	55.1	54.8	56.6	56.7	57.9	57.4	65.9	64.9	67.7	65.6	66.0	68.8	63.0	64.7	58.0	61.0	54.7	58.0	51.5	52.6
70%	50.0	50.0	51.9	51.8	55.3	55.2	56.7	56.9	58.2	57.6	66.0	65.0	67.9	65.9	66.2	69.2	63.3	64.8	58.2	61.3	54.8	58.2	51.6	52.9
72%	50.1	50.1	52.1	52.0	55.6	55.5	56.9	57.1	58.4	57.7	66.3	65.2	68.1	67.9	66.4	70.0	63.5	65.0	58.5	61.5	54.9	58.4	51.7	53.1
74%	50.2	50.3	52.2	52.2	56.0	55.8	57.0	57.3	58.7	57.9	66.6	65.4	68.3	68.4	66.6	70.5	63.7	65.2	58.7	61.7	55.0	58.5	51.7	53.3
76%	50.3	50.4	52.4	52.3	56.3	56.1	57.3	57.6	59.1	58.2	66.8	65.5	68.6	68.7	66.7	70.9	63.9	65.6	59.0	61.9	55.1	58.7	51.8	53.6
78%	50.4	50.6	52.5	52.5	56.7	56.4	57.5	57.8	59.5	59.4	67.1	65.7	68.8	69.2	67.0	71.1	64.1	66.0	59.3	62.2	55.2	58.8	51.9	53.8
80%	50.5	50.8	52.7	52.7	57.0	56.7	57.8	58.1	60.2	60.7	67.3	66.1	69.1	69.5	67.2	71.6	64.3	66.6	59.5	62.6	55.3	58.9	52.0	54.1
82%	50.7	51.0	52.9	52.9	57.3	57.0	58.1	58.4	61.4	61.9	67.5	66.8	69.2	70.0	67.5	71.8	64.5	67.5	59.6	62.8	55.6	59.0	52.1	54.3
84%	50.8	51.2	53.1	53.1	57.5	57.2	58.5	58.6	62.0	62.7	67.8	67.4	69.4	70.7	67.7	72.1	64.7	68.8	59.9	63.3	55.7	59.2	52.2	54.6
86%	50.9	51.6	53.3	53.3	57.8	57.4	58.8	58.9	62.4	63.2	68.0	67.9	69.6	71.3	67.9	72.4	64.9	69.6	60.1	63.6	56.0	59.4	52.3	54.9
88%	51.1	51.9	53.5	53.5	58.0	57.7	59.2	59.2	63.0	64.0	68.3	68.8	70.0	71.9	68.1	72.8	65.1	70.4	60.3	64.0	56.3	59.6	52.4	55.2
90%	51.3	52.2	53.7	53.7	58.3	57.9	59.5	59.4	63.4	64.7	68.6	69.2	70.3	72.4	68.3	73.4	65.4	71.0	60.5	64.5	56.5	59.8	52.5	55.6
92%	51.5	52.6	54.1	53.9	58.5	58.1	59.8	59.8	63.9	65.0	69.0	69.7	70.5	73.1	68.5	75.3	65.8	71.7	60.8	65.2	56.8	60.2	52.7	56.1
94%	51.6	52.9	54.4	54.2	58.9	58.4	60.3	60.3	64.5	66.2	69.3	70.3	70.9	73.9	68.9	78.4	66.1	72.6	61.2	66.1	57.0	61.0	52.9	56.9
96%	52.1	53.5	54.7	54.4	59.3	58.7	60.9	61.2	65.4	67.1	69.6	70.8	71.3	76.5	69.2	79.9	66.4	73.9	62.1	67.3	57.5	62.0	53.0	57.3
98%	52.5	54.7	55.1	54.9	60.0	59.3	61.6	62.3	67.0	68.3	70.1	71.5	71.8	81.0	70.0	81.2	67.9	75.4	63.6	69.7	57.9	62.7	53.4	58.1
100%	54.0	57.2	56.6	55.9	60.8	60.5	63.2	66.1	69.7	70.5	70.8	76.6	73.8	83.7	72.9	84.2	70.1	80.8	65.6	71.9	59.4	63.9	54.7	59.1
Case	2E	2ENL	2E	2ENL	2E	2ENL	2E	2ENL	2E	2ENL	2E	2ENL	2E	2ENL	2E	2ENL	2E	2ENL	2E	2ENL	2E	2ENL	2E	2ENL
Target	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	56.0	56.0	56.0	56.0	56.0	56.0

Above target Below Target